Ministry of Higher Education and
Scientific Research
University of Mosul
College of Computer Science and
Mathematics
Department of Computer Science

Competent Enhancement and Restoration for MR Images Using Multi Adapted Concepts

**A Thesis Submitted to the Council of the College of
Computer Science and Mathematics
University of Mosul
as a Partial Fulfillment of Requirements
for the Degree of Doctor of Philosophy in
Computer Science**

By

Manar Abdulkareem Zedan Thanoon

Supervised by

Asst. Prof. Dr. Zohair Qays Ibrahim Thanoon

2025 A.D. **1447 A.H.**

Abstract

Magnetic resonance imaging is a sophisticated medical modality. Despite its advantages, the generated images may exhibit degradations or distortions due to unavoidable factors that impact diagnostic accuracy. These degradations diminish the clarity of the image and degrade the overall image quality. which negatively affects visual perception and poses substantial hurdles to the accuracy of disease diagnosis.

This study introduces a new framework that can analyze the input MR image to determine the type of degradation it contains and handle it using the appropriate proposed algorithm. The framework includes three proposed algorithms as follows:

Algorithm 1 (S_LIP): S_LIP is a statistical-based algorithm proposed to improve MR image contrast. In the first stage, three types of transformations (Logarithmic transformation and two kinds of S_Curve Transform) are used to change the image's gray level and obtain three different images, each with different features. These images' features are combined to produce a new image using logarithmic image processing. Then, post-processing with S-Curve transform and linear stretching is applied to create enhanced images.

The S_LIP algorithm was compared with six different algorithms based on the concept, and two measures were utilized to assess the comparison. S_LIP outperformed them; it obtained the best performances according to average NSS=2.6409 and average VCM=380.7991. S_LIP produced clear images with natural contrast while well-illuminating the dark areas of the image without providing undesirable amplification.

Algorithm 2 (Adapted Fast Gradient Projection): This algorithm was introduced to eliminate Rician noise in MR images. It has two distinctly defined stages. The first includes a detail-emphasis phase in each iteration to enhance the high-frequency components. The second automatically computes the regularization parameter using the image's local data.

Based on the concept, the proposed denoising algorithm outperformed six different algorithms. The comparison was based on three measures. It's obtained the best performances, recording the lowest averages in PIQE= 47.3118, BRISQUE= 45.2244, and NIQE= 4.3877.

Algorithm 3 (Guided-Subsumed Unsharp Mask Filter): The proposed filter includes two main stages. The first is utilizing the improved guided filter instead of the low-pass Gaussian filter with an adaptive regularization parameter. The second involves using a dynamic sharpening process to control the sharpness level.

Also, the proposed filter was compared with six different algorithms based on three measures. GSUM outperformed them by achieving the best performances, recording the lowest averages in PIQE (28.4453) and Blur (0.6940), while achieving the highest average in Fish (6.1215) with a fast execution time.

In cases where images are affected by more than one type of degradation simultaneously, the previously described algorithms are combined according to the specific type of degradation.

Competent Enhancement and Restoration for MR Images Using Multi Adapted Concepts

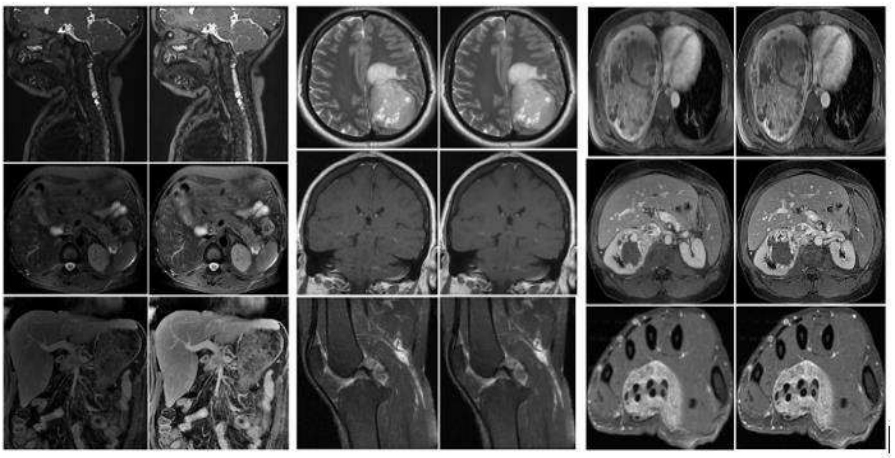
Author: Manar Abdulkareem Zedan Thanoon **Advisor: Dr. Zohair Qays Al-Ameen**

Publisher: University of Mosul

HIGHLITS

- Performance tests of all proposed algorithms were evaluated.
- S_LIP outperformed them; it obtained the best performances according to average NSS=2.6409 and average VCM= 380.7991.
- AFGP obtained the best performances, recording the lowest averages in PIQE=47.3118, BRISQUE=45.2244, and NIQE=4.3877.
- GSUM recording the lowest averages in PIQE (28.4453) and Blur (0.6940), while achieving the highest average in Fish (6.1215) with a fast execution time.

GRAPHICAL ABSTRACT



Keywords:

MR Images

Contrast Enhancement

Noise Removal

MR image Sharpening

Rician Noise

FGP

Unsharp Mask Filter

ABSTRACT

Magnetic resonance imaging is a sophisticated medical modality. Despite its advantages, the generated images may exhibit degradations or distortions due to unavoidable factors that impact diagnostic accuracy. These degradations diminish the clarity of the image and degrade the overall image quality. which negatively affects visual perception and poses substantial hurdles to the accuracy of disease diagnosis.

This study introduces a new framework that can analyze the input MR image to determine the type of degradation it contains and handle it using the appropriate proposed algorithm. The framework includes three proposed algorithms as follows:

Algorithm 1 (S_LIP): S_LIP is a statistical-based algorithm proposed to improve MR image contrast. In the first stage, three types of transformations (Logarithmic transformation and two kinds of S_Curve Transform) are used to change the image's gray level and obtain three different images, each with different features. These images' features are combined to produce a new image using logarithmic image processing. Then, post-processing with S-Curve transform and linear stretching is applied to create enhanced images.

The S_LIP algorithm was compared with six different algorithms based on the concept, and two measures were utilized to assess the comparison. S_LIP outperformed them; it obtained the best performances according to average NSS=2.6409 and average VCM=380.7991. S_LIP produced clear images with natural contrast while well-illuminating the dark areas of the image without providing undesirable amplification.

Algorithm 2 (Adapted Fast Gradient Projection): This algorithm was introduced to eliminate Rician noise in MR images. It has two distinctly defined stages. The first includes a detail-emphasis phase in each iteration to enhance the high-frequency components. The second automatically computes the regularization parameter using the image's local data.

Based on the concept, the proposed denoising algorithm outperformed six different algorithms. The comparison was based on three measures. It's obtained the best performances, recording the lowest averages in PIQE= 47.3118, BRISQUE= 45.2244, and NIQE= 4.3877.

Algorithm 3 (Guided-Subsumed Unsharp Mask Filter): The proposed filter includes two main stages. The first is utilizing the improved guided filter instead of the low-pass Gaussian filter with an adaptive regularization parameter. The second involves using a dynamic sharpening process to control the sharpness level.

Also, the proposed filter was compared with six different algorithms based on three measures. GSUM outperformed them by achieving the best performances, recording the lowest averages in PIQE (28.4453) and Blur (0.6940), while achieving the highest average in Fish (6.1215) with a fast execution time.

In cases where images are affected by more than one type of degradation simultaneously, the previously described algorithms are combined according to the specific type of degradation.

2025 PhD. Thesis @Univ. of Mosul, College of Computer Science and Mathematics, Computer Science Dept. (https://www.uomosul.edu.iq/).

وزارة التعليم العالي والبحث العلمي
جامعة الموصل
كلية علوم الحاسوب والرياضيات
قسم علوم الحاسوب

تحسين واستعادة كفوءة لصور الرنين المغناطيسي باستخدام مفاهيم مكيفة متعددة

اطروحة مقدمة
الى مجلس كلية علوم الحاسوب والرياضيات في جامعة الموصل
كجزء من متطلبات نيل شهادة دكتوراه فلسفة في
علوم الحاسوب

من قبل
منار عبدالكريم زيدان ذنون

بإشراف
أ.م. د. زهير قيس ابراهيم ذنون

١٤٤٧ هـ ٢٠٢٥ م

المستخلص

يعد التصوير بالرنين المغناطيسي وسيلة طبية متطورة. وعلى الرغم مزاياه العديدة، قد تتأثر الصور المُولَّدة بتدهورات أو تشوهات نتيجة عوامل حتمية تؤثر على دقة التشخيص. تُقلل هذه التدهورات من وضوح الصورة وجودتها العامة، مما يؤثر سلبًا على الإدراك البصري ويُشكِّل عقبات كبيرة أمام دقة تشخيص الأمراض.

تُقدّم هذه الدراسة إطارًا جديدًا يُمكّن من تحليل صورة الرنين المغناطيسي المُدخلة لتحديد نوع التدهور الذي تحتويه، ومعالجته باستخدام الخوارزمية المُقترحة المُناسبة. ويشمل الإطار ثلاث خوارزميات مُقترحة، كما يلي:

الخوارزمية١: خوارزمية S_LIP هي خوارزمية إحصائية مقترحة لتحسين تباين صور الرنين المغناطيسي. تُطبّق في البداية ثلاثة أنواع من التحويلات (التحويل اللوغاريتمي ونوعان من تحويلات S–Curve) لتعديل المستوى الرمادي في الصورة والحصول على ثلاث صور، لكل منها خصائص مختلفة. تُدمج هذه الصور لإنتاج صورة جديدة باستخدام نموذج لوغاريتمي. بعد ذلك، تُطبّق المعالجات اللاحقة باستخدام تحويل S–Curve والتمدد الخطي لإنشاء الصور المُحسّنة.

تمت مقارنة خوارزمية S_LIP بست خوارزميات مختلفة، واستُخدم مقياسان لتقييم المقارنة. تفوقت S_LIP على الخوارزميات الاخرى؛ حيث حققت أفضل أداء وفقًا لمعدل مقياس NSS = 2.6409 ومعدل مقياس VCM = 380.7991. أنتجت S_LIP صورًا واضحة ذات تباين طبيعي، مع إضاءة جيدة للمناطق المظلمة من الصورة دون إحداث تضخيم غير مرغوب فيه.

الخوارزمية ٢: فهي خوارزمية إسقاط التدرج السريع المُعدّلة (Adapted fast gradient projection) لتقليل الضوضاء من نوع Rician في صور الرنين المغناطيسي.. تتألف من مرحلتين مُحدّدتين بوضوح. تتضمن الأولى مرحلة تعزيز التفاصيل في كل تكرار لتحسين مكونات التردد العالي. أما الثانية فتحسب مُعامل التنظيم تلقائيًا باستخدام البيانات المحلية للصورة.

بناءً على المفهوم، تفوقت الخوارزمية المقترحة على ست خوارزميات مختلفة. استندت المقارنة إلى ثلاثة مقاييس. حيث حققت أفضل أداء، مُسجّلةً أدنى المعدلات في PIQE = 47.3118، وBRISQUE = 45.2244، وNIQE = 4.3877.

الخوارزمية ٣: هي مرشح Guided-subsumed unsharp mask، يتضمن المرشح المقترح مرحلتين رئيسيتين. الأولى هي استخدام المرشح الموجه المُحسّن بدلاً من مرشح غاوسي منخفض التردد مع معامل تنظيم تكيفي. الثانية هي استخدام عملية شحذ ديناميكية للتحكم في مستوى الحدة.

كما تمت مقارنة المرشح المقترح بست خوارزميات مختلفة بناءً على ثلاثة مقاييس. تفوق المرشح المقترح عليها بتحقيق أفضل أداء، مسجلةً أدنى المعدلات في PIQE=28.4453 وBlur=0.6940، بينما حققت أعلى معدل في Fish=6.1215.

في حال وجود صور تعرضت لأكثر من نوع واحد من التدهور في الوقت ذاته، تُدمج الخوارزميات السابقة بما يتناسب مع كل نوع من أنواع التدهور.